Can Satellite Geodesy Disentangle Holocene Rebound and Present-day Glacier Balance Signatures?

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The secular drift of the precession of the ascending node of the LAGOES- 1 satellite is apparently linked to the Earth’s paleoclimate through the slow viscous response of the mantle to ice sheet/ocean mass transfer during the last great continental deglaciation circa 21-5 ka BP. The secular node acceleration is particularly sensitive to the longest wavelengths of the palco-surface loading that have been “memorized” by the mantle glacio-isostatic flow. The most sensitive term is the rate of change in oblateness, or second degree zonal gravity coefficient, $\dot{J}_2$. The complete secular drift sensitivity for LAGEOS- 1 is expressed as

$$4.16\,\dot{J}_2 + 1.54\,\dot{J}_4 + 0.33\,\dot{J}_6 + \text{ small higher order even} - l \text{ terms}$$

[Cheng, et al., 1989 GRL 16] and is consistent with the predicted post-glacial rebound (PGR) $\dot{J}_2, \dot{J}_4, \dot{J}_6$ signature. Tide gauge records that encompass a continuous 130 year period reveal a PGR corrected *[Peltier and Tushingham, 1991 JGR 96]* sca-level rise signature of $\dot{\xi} = +2.4 \pm 0.9$ mm yr^{-1}. An assessment by *Meier [1990 Nature 343]* includes the following quantifiable sources of this secular rise:

Steric Expansion:	0.2 ± 0.1 mm yr^{-1}
Small Mtn. Glaciers:	$0.5 \pm$ (3.3
Anthropogenic:	< 0.2

This means that there might be a large (≈ 0.7 mm yr^{-1}) source originating from a net negative imbalance of Antarctica plus Greenland. Glaciologically-based estimates, though, for the vast continental ice sheets vary widely. A recent revision of Antarctic balance by *Jacobs [1992 J. Glac. 38]* indicates that a missing 1 mm yr^{-1} might be explained by increased ablation rates near the grounding lines of the Antarctic ice shelves. The predicted $\dot{J}_l$ of this scenario *[James and Ivins, 199.5 GRL 22]* are: 1.8, 1.9 and 1.6 (units of 10^{-11} yr^{-1}) for l = 2,4 and 6, respectively. The latter rates arc large enough that they erode clean interpretations of post-glacial rebound $\dot{J}_l$ signals. Revisions in mantle viscosity structure and/or palco-load history are implied and future successful solutions require: (1) an improved resolution of odd degree-related orbit drift, (2) continuous multi-year tracking of 4 or more satellites *[Nerem and Klosko, 1995 GRL, in press]*, and (3) improved constraints on the timing of Holocene collapse of the West Antarctic icc sheet. We propose that measurement of vertical uplift signature using GPS near the Ross Embaymcnt in Antarctica could provide a key constraint on Holocene retreat history of the Antarctic ice sheet. Odd degree harmonics are quite sensitive to the timing of southern hemispheric deglaciation.